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1923
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Engineering

M. WILSON. President | W. A. BOOTH Secretary | P. P. REYNOLDS Treasurer

OFFICIAL PROCEEDINGS
Meeting of January, 1923.

Volume XXII.
No. 1.

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INCORPORATED OCTOBER 1918

Canadian Railway Club

MONTREAL

PARVA SUB INGENTI

CONTENTS:

Report of January Meeting

and

Paper and Discussion on

"The KILN-DRYING of LUMBER."

AUG 19 1943

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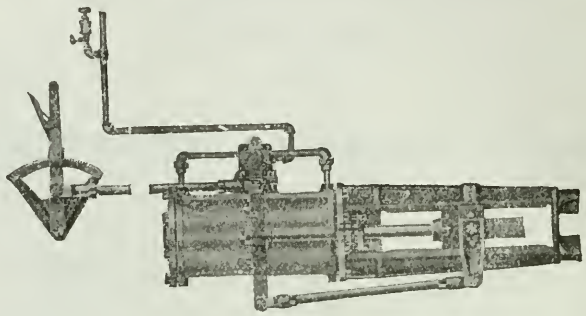

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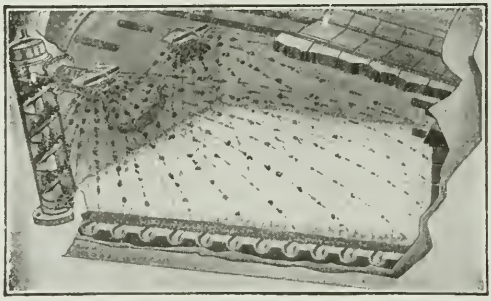

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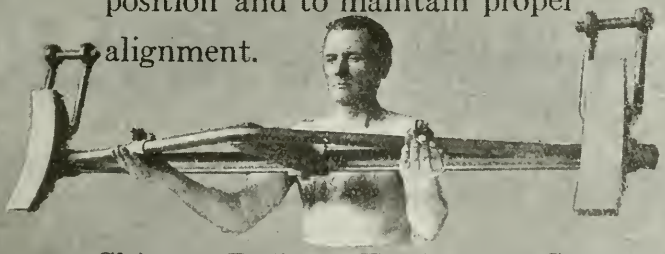

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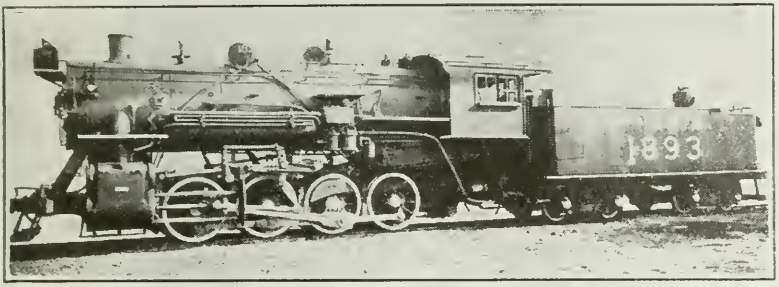

Total weight of engine, 243,000 pounds
Weight on drivers, 243,000 pounds
Diameter of drivers, 56 inches
Boiler pressure, 200 pounds
Cylinders, 26 x 30 inches
Maximum tractive power, 52.300 pounds

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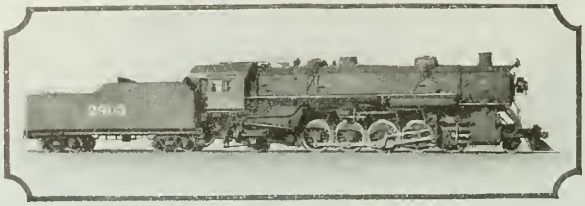

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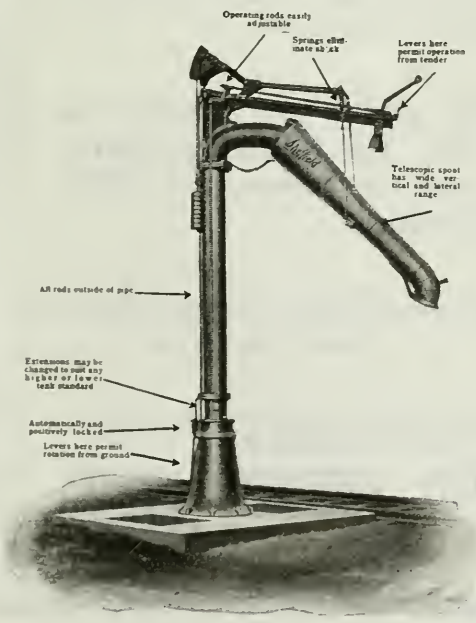
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Springs eliminate slack
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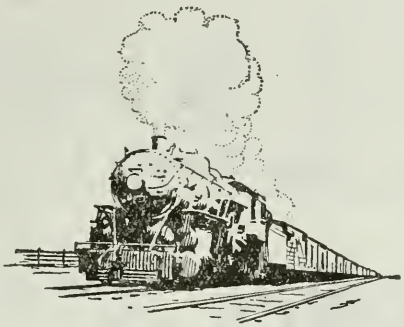

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W. A. BOOTH, Secretary, 53 Rushbrooke Street, Montreal.

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PROCEEDINGS OF THE CANADIAN RAILWAY CLUB

Windsor Hotel, Montreal,
January 9th, 1923

Chairman (Mr. G. M. Wilson):

Gentlemen, I am pleased to see you at the meeting to-night. There is no doubt but that we have had a very enjoyable Christmas and perhaps, that explains for a larger number not being present with us to-night. However, we greet you very cordially, and if you will kindly fill in the attendance cards now, I will be much obliged.

MEMBERS PRESENT

Anderson, H.
Atkinson, T.
Battley, E. R.
Brandon, J. D.
Brazier, G. W.
Brown, L.
Buckle, W. E.
Candlin, A. J.
Chaffe, A. B.
Chian, E. T. Y.
Coleman, M. T.
Crockett, W. B.
Desparios, D.
Dohm, J. T.
Dow, A. W.
Farey, F. O.
Faughman, B.
Ferguson, B. H.
Ferguson, T.
Fildes, A.
Hanson, L. J.
Hearn, J. N.
Hendry, J.
Jones, D. T.
Lammers, W.
Lane, N.
Lane, W. J.
Loughren, A. J.
Lowe, W. S.
Luker, G.
Manhard, W.
Masse, B.
Maurice, W.
Miller, M. J.
Miller, W.
Milord, J. P.
McAllister, L. H.
McAllister, W. J.
Naylor, H. R.
Needham, R. J.
Palmer, E. B.
Parsons, H. J.
Parker, W. J.
Peterson, W. A.
Pierpoint, F. H.
Playfair, J.
Richardson, P.
Serchuch, H. W.
Shaw, R. O.
Stuart, H. B.
Teleier, F. J.
Tilt, E. B.
Tinkler, J. E.
Tompkins, G. A.
Towne, A. C.
Tubman, W. J.
Viberg, E. R.
Warner, G.
Watkinson, A.
Wheatley, G. H.
Whitrod, W.
Wilson, R. R.
Wilson, G. M.
Winship, R. B.
Booth, W. A.
And Many Others.

I will now ask the Secretary to read the minutes of the last meeting;

Secretary (Mr. W. A. Booth)

Mr. Chairman, I presume it will be quite satisfactory to the members present for me to omit the reading of the minutes as they have been printed and mailed to-day, something like 1,800 copies being distributed through the mail of Mr. Viberg's paper on "Present Day Tendencies in Car Construction." I will now read the names of the new members that are before us to-night.

NEW MEMBERS

Dunn, C. A. Can. Oil Co., 4 Maylor Street.
Main, D. T. Engr. of Sales & Works Inspector, Nat. Steel Car Co., Hamilton, Ont.
Miller, G. Machinist, Can. Pacific Rly., Angus Shops.
Morris, A. C. Can. Oil Companies, Ltd., Excelsior Life Bldg., Toronto, Ont.
McAllister, L. H. Upholsterer, Angus Shops, Can Pac. Rly.
McConnell, G. T. Chief Electrician, Can Steel Foundries.
Parisien, W. A. Can. Oil Co. Montreal.
Prizeman, J. Car Foreman, Grand Trunk Rly. Montreal.
Robertson, F. J. Travelling Auditor, Can. Pac. Rly., Montreal.

Mr. G. M. Wilson:

You have heard the names of the applicants for membership, gentlemen, will someone please move that they be accepted?

(Moved by Mr. H. R. Naylor and seconded by Mr. J. Atkinson, and carried.)

Chairman:

The next order of business is the Chairman's remarks.

"I do not know very much to say to-night, except that perhaps you would take note that the Secretary mentioned on the Post cards that I would have something of special interest to mention to our members to-night. When he placed that note on the cards, he evidently had in mind our 20th Annual Banquet, which is to take place on Saturday evening, the 27th instant, in this Hotel, and we have arranged for two prominent speakers for that occasion.

I trust that we shall follow that saying made by "Cato," who said, "He approaches nearest the gods who knows how to keep silence, even though he is in the right."

From what I can learn, we are going to have an exceptionally good time and our special committee are working hard to give you, not only a good menu, but have procured the services of some of the best local talent and theatrical vaudeville, so I trust each and all will make it a point to come along on that evening and you might also invite your friends, when we can assure you of a night well to be remembered.

We all want to demonstrate to our speakers and invited guests, that the membership of this Canadian Railway Club of ours, is made up of Gentlemen, in the strictest sense of the term."

I have now the pleasure of introducing Mr. F. O. Farey, Chief Chemist, Robt. W. Hunt Co., Montreal who will read his paper entitled "The Kiln-Drying of Lumber."

KILN DRYING OF LUMBER

Mr. Chairman, Members and Friends of the Canadian Railway Club:

The subject as read to you "The Kiln drying of Lumber" is considered by the writer as being much broader than implying the actual process of eliminating the water content of the wood and involves a study of the kiln itself, the various schedules for drying the lumber (if indeed they may be called schedules) and last but by no means the least important is a study of the condition which we wish to obtain in the finished product.

I may say at the beginning that my personal experience with the actual processes in the kiln has been limited and that undoubtedly others are more qualified to speak on this particular phase than myself, but for several years the speaker has had occasion to study the finished product and has on several occasions carried out investigations to determine the best properties of lumber for various purposes.

In my work I have not hesitated to accept authentic research which has been conducted by others and refer particularly to the studies of the Forest Products Laboratories of the United States Forest Service at Madison, Wisconsin. These investigations are considered most authentic and I shall refer to their work during this paper and give you some of their results in detail.

I wish also to acknowledge the assistance given me by the Canadian Pacific Railway, the Grand Trunk Railway, the Canada Car Company, and also to the R. W. Hunt & Co., Ltd.,

who have made a large portion of my experimental work possible.

The type of Kiln in most general use is the compartment kiln, in which the circulation of air is up in the center and down and out at the sides, and also the progressive kiln, in which the circulation of air is from one end to the other.

As the name implies, the compartment kiln or series of kilns, are built up in units of a capacity and number to meet the demands made upon them. The heating coils are usually laid in the pit lengthwise the unit, and are 12″ to 18″ below the floor or below the framework on which is piled the lumber, or on which the cars carrying the lumber are run. The intake of the air supply is so situated at the bottom as to allow the cold air to be heated by the coils before it passes into the pile, at a uniform temperature and humidity. This air current passes upward and outward through the properly piled lumber and is carried off through ventilating holes in the side of the kiln to the chimney. These ventilating holes are situated in the side walls from one fourth to one half the distance from the bottom of the kiln to the top and are about 3″ x 6″ in size and arranged to give an equal ventilation for the whole unit.

The construction of the kiln may be made of any one of the several materials, such as lumber, cement, tile, brick, etc. Of course, where a battery of kilns are being operated the wood construction increases the fire hazard materially, since, if a fire started, the whole battery and contents may be destroyed. Wood makes a good insulation but should be given a good coat of asphalt paint to prevent in a measure the rapid absorption and evaporation of moisture. This is especially true when the side walls are made up of 2″ x 6″ planks laid flatwise. The continuous working of the walls is liable to cause considerable trouble with the door jambs, ventilation and pipe ports.

Concrete (either monolithic or block) should be thoroughly waterproofed, otherwise difficulty may be encountered when maintaining high humidities. Brick or hollow tile are generally considered the best materials. These should be painted with an elastic cement and repainted as hair cracks gradually appear. If hollow tile is used in construction the openings of the blocks should run horizontally rather than vertically, as this will prevent air circulation in the walls.

The writer has seen kilns of the compartment type where the whole heating coil system has been left open under the lumber and the air supply admitted only by the uncertain

hazard of natural cracks and openings in the doors or around the sides of canvas curtains. It seems, however, that this is a very unsatisfactory method and that it is much preferable to have a flooring over the coils with vents to allow uniform distribution of hot air into the kiln and a regulation to control the supply of air through the main intake. Then the bottom of the pile should be 12″ to 18″ above the floor. Many kilns are not equipped with steam intakes to control the humidity of the chamber.

An example is given to show the effect of this method. The air as taken may be at a temperature of 20° F. and its relative humidity 60%. This air contains .7 grains of moisture per cubic foot. This air is heated to 120° F. as it enters the kiln for green or partially seasoned lumber. At 120° F. the saturation point of air is 34½ grains per cubic foot, giving a relative humidity at that temperature of only 2%. Of course, this condition is only temporary, as the moisture from the lumber soon raises the humidity, but the drying action on the nearest exposed surfaces is tremendous, and soon causes checking, especially of hard woods and large timbers. This seems to be ample proof that all kilns should be equipped with steam or spray humidifiers, since some woods require a humidity as high as 85% at the start of the operation and the only way to eliminate case hardening or unequal stresses is to raise the humidity of the kiln to nearly 100% at the temperature at which the kiln is operated. This will require 90 grains of moisture per cubic foot, where the kiln is operated at 160° F. Further reference will be made to this phase during the progress of the paper.

Another feature which seems to be of vital importance in the design of the compartment kiln, is the heating system. Here I may be treading on dangerous ground, since each manufacturer has his own special design and hook up. The idea was first brought to my attention in technical note No. 90 of the U. S. Forest Products Laboratories. Some kilns are equipped with the Header System of heating, that is, the steam is admitted at one end of the system and drainage traps, etc., are at the other end. The writer had studied temperature conditions under this system and noted the considerable difference of temperature between the two ends of the kiln. This is indeed vital, especially where hard woods or timbers are being treated. At one end the lumber may dry too rapidly, while at the other end no drying action is taking place, even mould may develop. A remedy for this condition has been

given and applied with favorable results by using the return bend heating coil. Here the steam entering at the initial temperature gradually cools on its way to the other end and continues to cool on its return to the starting point. Approximately the sum of the temperature at one end of the system is the same as the sum of the temperature of the coils at the other end. By this means a more uniform temperature is obtained throughout the unit. This is particularly so when low steam pressures and low temperatures are being employed.

The other principal type of drying kiln is called the progressive kiln by having an end to end circulation of air rather than the vertical-lateral direction. The steam coils, humidifiers, etc., are located below the floor, the air comes up at one end of the kiln, passes horizontally from one end to the other through the piles of lumber and out at the vents in the lower half of the side walls at the other end of the kiln. The platform carrying the lumber trucks are located high enough from the floor to furnish suitable ventilation.

The principle of this type is that of a continuous operation. The driest lumber is moved toward the source of heat while new charges are put in at the cooler end.

It is said that this kiln requires less skill in manipulation and consumes less heat per pound of water evaporated than the compartment kiln. It is, however, of greatest value where lumber of uniform thickness and moisture and the same general types of lumber are being supplied. The Compartment Kiln is almost essential where various kinds of lumber are to be treated at the same time and especially where various sizes are used and different stages of air seasoning has taken place before putting into the kiln.

After considering the kilns, how shall we obtain the best results from the apparatus which we have available? It is an admitted fact that as much lumber can be destroyed in one type of kiln as in another or almost as good results may be obtained with one kiln as another. The whole system depends almost absolutely on the ability, judgment and care of the operator. Probably one of the most essential points is the way lumber is piled to make the kiln most efficient. Proper utilization of available space and proper circulation of air are prime requisites. You cannot pile lumber in a progressive kiln the same as you pile it in a compartment kiln with vertical-lateral circulation. This has been tried and very definite data has been recorded to prove the point. For the compartment kiln it seems that lumber must be piled endwise so that the stick-

ers will not obstruct the circulation and form cool pockets in the pile. If this passage is obstructed the lumber at these points will dry more slowly and you will have a variable product at the end, not only in moisture content but in checking, internal stresses, and warping, both in and after removal from the kiln. The natural passage of the air is originally vertical between the piles and then laterally between the boards to the sides and vent holes. If the stickers block this passage as in cross piling it is almost impossible to get a circulation between the boards to such an extent that the outsides of the pile will be dry and check while the inside will retain a large percentage of moisture.

For the progressive kiln the conditions are reversed. Cross piling is almost essential so that the stickers will not obstruct the passage of air as it progresses from one end of the kiln to the other. An example is given of two piles of lumber in the same kiln having vertical-lateral circulation. On the eighth day when we would have assumed that the temperature would have been fairly uniform the thermometer readings were as follows:—

	Cross Piled Lumber	End Piled Lumber.
Centre of pile	110° F.	142° F.
Underneath	168° F.	152° F.
Above	146° F.	146° F.

The difference in temperature between the center and bottom of cross piled lumber was 58° F., while the difference in end piled lumber was 10° F. This record shows that the end piled stock dried in ten days from 30% moisture to 6%, while the cross piled stock took 13 days to dry from 30% to 12%. In a kiln with end to end circulation the reverse conditions would have been true. It is obvious that lumber should be piled to suit the circulation of the kiln with a view to give the best passage of air through the pile and maintain all parts of the pile at as nearly the same temperature as possible. This can only be done by using the best judgment of the operator and carrying on such experiments as will prove or disprove the correctness of that judgment. Not only must consideration be given to the direction of piling and placement of the stickers, but the size of each pile and the thickness of the stickers depending on the thickness of the sections and the width of the lumber stock. It would seem good practice not to have any sticker less than one inch thick and this should be increased to not less than two inches when the thickness of the lumber sections is three inches or greater.

The best method of testing the circulation of air in a kiln is to make some kind of smoke cloud. The Forest Products Laboratories at Madison have devised a chemical smoke which eliminates fire risk and which follows the natural air currents with no tendency of its own to rise or fall, which is the objection to some other smoke clouds. They make a small box with a handle just to hold, two wide mouth bottles, such as common ink bottles. Into the first bottle is inserted a two-holed rubber stopper. Into one hole of the stopper is placed a three inch piece of glass tubing bent in the middle at right angles, and on the outside connected with two or three feet of rubber tubing three-sixteenths inch bore. The glass should extend only slightly below the bottom of the stopper. Another piece of similar glass tubing bent into horse-shoe form is inserted in the other hole of the stopper and is sufficiently long to extend into the mouth of the other bottle for about one-half inch below the neck. The first bottle is one-third filled with strong hydrochloric (muriatic) acid and the second bottle is filled to about the same depth with strong ammonia. The glass tubes should never touch the liquids—preferably the distance from the liquids should be one-half inch to one inch. By blowing through the rubber tubing the vapors of the hydrochloric acid are forced over to meet the vapors of the ammonia to form a cloud of ammonium chloride. This cloud may then be watched during its passage through the kiln. The cloud preferably may be taken in at the air inlet or placed in some advantageous place in the kiln and this rubber tube or a longer one may then be run to the outside through a small hole bored through the wall or door near some observation point. All this presupposes that there are advantageous observation points and that the kiln is lighted. Ventilation must be positive and continuous through all parts of the kiln if the best results are to be obtained, either in the resultant product, the speed of the operation or from a point of cost. This is true whether you are drying small sections of soft woods or larger sections of the refractory hard woods.

While the smoke cloud is a valuable means of assuring ourselves whether or not we are getting positive circulation, it is not all that we are required to know about what is going on in the kiln. We must, at all times, know the temperature and humidities not only at each end near the doors or peep holes, but inside and near the lumber piles themselves. This requires the use of thermometers and hygrometers of various types. Probably the best of these are the glass thermometers

and the wet and dry bulb hygrometers. Of course the dry bulb of the glass hygrometers is a thermometer in itself. It is, however, difficult to use the wet and dry bulb thermometers in every case, since no one would care to enter a dry kiln every two or three times a day to observe the temperature inside of a pile of lumber, especially when some of the higher temperatures are being reached. It might be a means of acclimating ourselves to that well known future habitation, but we will take our chances. However, this knowledge must be obtained and a means is provided by the use of recording thermometers and hygrometers. The recording instruments, notwithstanding some of the claims of the manufacturers, must be continually checked against wet and dry bulb glass instruments of known accuracy.

One thing especially should be watched and that is the wet bulb of the hygrometer. Only pure distilled water should be used for filling the hygrometer wells and the silk or muslin covering for the bulb should be kept in good condition, and changed from time to time. A small amount of dust or solid material always collects in the meshes and sooner or later this deposit will impede the transfusion of moisture and render the readings valueless. Place no instrument where it will be affected by direct radiation from a cool wall or from the heating coils, as this only leads to erroneous data from which improper conclusions will be drawn. There are numerous types of recording and non-recording instruments on the market by which temperatures and humidities may be determined, at any point in the kiln. Directions for installation and use of these instruments are furnished by the manufacturers but these should always be checked against a standard instrument of the glass type. In reading the wet bulb thermometer, there should be a sufficient circulation of air to give a maximum evaporation rate. This requires about fifteen feet per second at temperatures below 120° F. At higher temperatures this rate is not so essential, but a thorough fanning is usually required. No operator should hesitate to ask his employer for neeessary instruments, which will enlarge or facilitate his knowledge of what is going on in the drying chamber, and then to ask for such means as may be necessary for the rectification of unsatisfactory conditions. It may cost a few dollars to properly equip a kiln, but any management which takes unnecessary chances with thousands of dollars worth of lumber, at the present time, is exercising a short-sighted policy.

The question is continually asked as to the proper drying schedule for a certain kind of lumber, whether one wood is easier to dry than others, what temperatures we can use and chiefly, how can lumber be dried in a shorter period of time? It is easier to dry some kinds of wood than others. Lumber will dry faster in thin sections naturally, since the distance through which moisture must transfuse from the interior is less. Also certain woods, such as many of the so-called soft woods, allow the transfusion to proceed at greater speed. Relative densities of the same species, relative proportion of Spring and Summer wood, also the direction of the grain in the sawed timber affect the time and treatment.

From this it will be seen that very much depends on the judgment of the operator of the kiln, after he has thoroughly examined the material which he is called upon to handle. He should know, within relative narrow limits on some woods, the moisture content. This cannot be determined by feeling the wood despite the claims of many wood workers. The only reliable way is to cut off a section of the board or timber at least two feet from the end and actually determine the moisture content by drying and weighing. A cross sectional sample is usually sufficient, but at times it is necessary to know whether the moisture is the same on the inside and outside of the section under examination. Also at times it is necessary to know whether there are internal strains existing in the lumber even though the moisture may be uniform and no surface checks are noticed. These strains are set up in air drying as well as in kiln drying and unless stresses are relieved by steaming you will, in all probability, increase the defects which already existed at the beginning.

The term "steaming" does not necessarily mean turning in a steam hose and filling the chamber with a cloud of steam, which will condense and give a wet surface to the wood, but by introduction of water vapor by steam or other means, so as to increase the relative humidity to 95 or 100 percent at the temperature at which the kiln is being operated.

It will probably flash through some of your minds that even in the same batch of lumber there will be a wide variation. Some will show higher moisture than others, some will show checks and internal stresses, while other portions of the charge will be normal. A sufficient number of tests must be made to at least know the worst condition with which you have to deal. The kiln should then be operated to suit the conditions of the poorest lumber. Then, too, it will be said

that all these precautions render its adoption in commercial practice impossible. Each operator must know how carefully each charge must be handled and how good he wishes this resultant product. You would not treat rough lumber for some construction with the same respect as you would lumber for expensive furniture. But, as said above, this is where the good judgment of the operator is essential.

When the original condition is known the operator must then decide what treatment must be given.

It is not within the province or scope of this paper nor is it possible to give hard and fast schedules for any given lumber. There is, however, a quite extensive series of schedules which have been worked out by the Forest Products Laboratories at Madison, Wisconsin, and given in a sheet known as Technical Note, Number 175, under the Heading of Hardwood and Soft Wood drying schedules. This can be obtained upon request from that Laboratory, and is valuable as a guide both to new and experienced operators, since one is often called upon to treat wood which is different from the kind usually handled, and a reference to these schedules will put the operator on his guard as to the general or comparative way which each particular wood should be treated. Differences in equipment and the way in which the wood responds to the treatment will tell the experienced operator how and when these schedules may be modified.

It is not desirable that the writer should incorporate these treating methods in detail as given in this booklet. However, it may be stated that the treatment of soft wood is divided into three general schedules which are each modified into three or four subdivisions depending on the kind of wood and the thickness of the sections and original moisture. The initial temperature for the most severe treatment varies from 180 to 200 degrees Fahrenheit, and a relative humidity from 85% to 30% depending on the original moisture content of the stock, down to the mildest treatment having an initial temperature of 135 degrees F. and 85% humidity. The temperature is raised in this schedule to 175 degrees F. and the humidity is lowered to 30% as drying progresses at definite stages as shown by the moisture content of stock removed from time to time from the kiln. The hard wood schedules are divided into eight distinct divisions. The most severe treatment compares very closely with the mildest soft wood treatment for basswood and birch up to 1½ inch thickness down to the mildest treatment where the initial temperature of 105

degrees F. and relative humidity 85% and a final temperature of 135 degrees F. and a relative humidity of 40% as drying progresses. The latter schedule being applied for certain southern low land oaks of 1½ inch thickness.

May I digress for a moment for those not thoroughly familiar with wood, to say that structurally soft woods are generally classed with what are commonly known as Evergreens, and the deciduous trees which lose their foliage periodically are generally classed as hard woods. This may jar our imagination when I say that basswood, boxwood and poplar are classified with Maple, Chestnut, Walnut, Mahogany and Oak, under the term of hard woods.

To proceed again, there seems to be a point in the drying of all woods up to which, or possibly, down to which, the greatest care must be exercised. From green timber with high moisture content down to a moisture content of about 25 to 30 percent, based on oven dry weight, our greatest care is required. This is what is known as the fibre saturation point of practically all wood. Above this, water exists in the cells in a free condition and must be eliminated slowly and uniformly. Below this percentage the water is physically or chemically combined with the fibres, and drying usually may be somewhat hastened.

It has been proven that no shrinkage occurs in wood above the fibre saturation point, water being gradually evaporated from the outside sections without any change in volume of timbers. As soon as there is a difference in water content a gradual transfusion takes place from the inner sections. This proceeds until the outside fibres contain a moisture below the fibre saturation. Then shrinkage starts around the outer portions but does not yet start in the inside. Thus you have an outside area trying to reduce its volume, but prevented from doing so by a resistant interior. One of two things is bound to happen when this condition exists, either the tension will become so great on the outer fibres that they are no longer able to stand the strain, and the wood starts to check or these outer fibres will take a set in an expanded condition, allow the passage of water from the interior to pass through them and finally completely dry out themselves without taking their normal shrinkage. The interior sections as they lose their moisture consecutively below the fibre saturation point have a tendency naturally to shrink. Here there are two opposing forces at work. The innermost zones still have their original volume and are under pressure and the

intermediate zone is in tension as occurred in the outer fibres originally. One of three things may now happen. If the outer fibres had started to check, the probabilities are that the intermediate section will check in the same place, since at that point there is no fibrous bond between the intermediate and outer zones. If the surface had set in an expanded condition one of two things may happen. The fibrous bond with the outer portion may be sufficient to hold the interior to the same volume and the whole section dry and set in an expanded condition. This may or may not be given the term "case hardened." If the fibres of every zone have set uniformly throughout it is not called "case hardening" but simply a set in an expanded condition. If, however, the setting or shrinkage has not been uniform when the moisture content throughout the section is the same, and there are set stresses existing throughout the different zones, the condition is called "case hardening." If these internal stresses exist to a sufficient extent due to internal shrinkage, and the fibres are not strong enough to withstand the tension put upon them, either the annular rings will separate, producing "shakes" or checking will proceed radially, giving a honeycombed condition.

You all know the value of lumber or timber which is honeycombed, shaky or checked, depending upon the visible extent of these conditions. However, there is no visible means of detecting wood set in an expanded condition, but after the lumber has been taken from the kiln, the fibres usually begin to take up moisture from the air, the set and set stresses are relieved at first on the outside setting up other stresses of a reverse nature. These outer zones are now in a condition to shrink in their normal course when allowed to dry again. This will cause checking and warping. If, however, the lumber which has set in an expanded condition is allowed to pick up moisture throughout the whole section all set and set stresses are relieved and the whole board or timber will be in a condition to shrink normally, as it would have done if the drying had been properly carried out. One is thus liable to have a large shrinkage in a section when the moisture content was relatively low as it came from the kiln.

Contrary to the opinions of many, it is the writer's view that the moisture content is not a criterion of future shrinkage, nor is the shrinkage obtained in the usual tests made immediately upon removal from the kiln a direct index of the shrinkage which may occur when the lumber is put into service.

While the writer was preparing this paper an idea occur-

red to him which may be of value to the testing departments concerned. Time would not permit working this out in detail, but the principle is this:—Take the narrow section to be used for moisture and shrinkage tests as it comes from the kiln, weigh and measure, and then allow to stand in a moist chamber for a period of time to relieve any set which exists. Then redry at temperatures which will prevent any tendency to set. This is purely an idea which did not develop in time to make the necessary experiments to prove its value, so this work is left for any interested parties.

A cry may go up from some of the kiln operators if more time is required for testing purposes than has been usual, however, these tests may not be necessary for routine work but performed periodically, if proven of value, as a guide to the operator.

Possibly a digression has been made which will not interest some of you, who are more interested in the prevention of the conditions alluded to and their detection in the early stages before too much damage has been done.

As stated before, about 25% moisture on the oven dry weight of the samples is the fibre saturation point of most woods, and a point under which it begins to shrink.

In looking over the drying schedules suggested by the research work done at Madison, it is noticed that the initial humidities range from 80 to 85%, which, at the usual temperatures, especially for hard woods and some soft woods, gives a condition which will prevent the outside fibres under any circumstances from drying below 15 to 20 percent. In view of the fact that moisture is being transfused from the interior, the moisture in the outside areas are maintained at or about the point at which shrinkage occurs and the speed of the evaporation for different woods is regulated by the temperature. As the 25% saturation point is approached for the entire stock, the outside areas dry further and begin to shrink. Here is where trouble is liable to occur, either from checking or case-hardening. Here the contents of the kiln must be watched to observe how the wood is reacting, and it is also very desirable to remove samples from the kiln and test in a manner which will be described later.

At the sign of checking, hollowing, or pinching of surfaces or internal stresses as determined by test, measures must be taken to counteract the action. Surface areas must be allowed to take up moisture to relieve strains by increasing the atmospheric humidity to a sufficient degree. Introduction of

steam in sufficient quantities is the usual method, and where the moisture content of the wood is relatively high, say, around 15%, humidity is increased to 100% from one half hour to several hours, depending on the extent of the trouble. Not any more than six hours for each inch thickness of timber is practically certain to relieve the most severe conditions. Temperature is often raised 20 to 30 degrees during the steaming and, if so, care should be taken to allow the kiln and stock to cool to the drying temperature before materially lowering the general humidity of the kiln.

Steaming should be resorted to at any time that danger appears and may be required several times during the period of drying. It also raises the temperature of the interior of the timber, thus allowing a more rapid transfusion of moisture, but unnecessary steaming or over steaming may do more damage than good by working the wood and slowing the process. No detail of this paper can tell an operator how much to steam, but it must be left to his own good judgment with each individual charge in his kiln. Many operators never enter a kiln, and it is not the most pleasant thing to do, but it is a means of saving much valuable timber and nip your troubles in the bud.

Your timber should be examined before it goes into the kiln, not only for moisture content as a whole, but you may have checking and case hardening conditions when received as well as in the kiln. In this case steaming is the only remedy to relieve initial stresses. Also you may have mouldy conditions or mould may develop in the kiln under low temperature and high humidities. This mould may be killed by steaming at 170 to 180 degrees F., for not more than an hour and maintaining a 100% humidity with live steam. The quicker the temperature is brought up the better, as it is not desirable to heat the interior of the timber more than necessary, and it is essential for the kiln to cool to drying temperatures in nearly saturated atmosphere.

Also some steaming may be resorted to at the end of the drying process, especially if tests show that there are any stresses existing and interior moisture above 7%. Many of you are acquainted with the method of testing lumber during the process of drying, or at the end, but to others it is not so familiar.

Remove from the kiln, samples, which will be representative of the stock. These may be placed when the charge is laid, so that they may be easily removed as desired. Cut off ends for about two to three feet so that it will not be effected

by end drying. The Forest Products Laboratories have devised the following tests, which have been used by the writer and they make certain recommendations for the rectification of unsatisfactory conditions.

Four one inch cross sections are now cut from the board. The first section is dried at 212 degrees F. if the average moisture content is desired. A second section is sawed parallel with broad side of the board and one half inch from the outside if the stock is two inches or more in thickness, or one fifth the thickness of the board if under two inches. Moisture is determined on this outside section. Trim an equal amount from the other three sides of the remaining part and determine the moisture. This will give an idea as to the uniformity of drying.

A third section is sawed parallel with the broad side of the original board, leaving, if possible, one half inch of solid wood and do the same thing on the other side. Two sawings are made on boards up to two inches thick, and five sawings are made on thicker boards. For sections having three prongs, remove the centre one. For sections having six prongs remove the second prong from each side. Sawings, of course, should be made only about three quarters through the section, or at least leave enough solid wood to hold the prongs rigid. The fourth section is simply sawed down the middle to represent resawed lumber.

Observe the action of the prongs immediately after sawing, and then set the specimens in a warm room to dry. If the prongs remain straight on the saw and, after room drying, the lumber is free from stresses and of uniform moisture content, or if they turn in on the saw, but become straight on drying it requires no special treatment.

If the prongs remain straight or turn out on the saw, but turn in on room drying, the moisture is uneven and the outside has set in an expanded condition. If the moisture ranged above 18% steam at 160 degrees and 100% humidity for one half hour to three hours; if moisture is below 18% the charge should be treated at 160 to 185 degrees and a humidity that will just permit moisture to be taken up.

If the prongs turn in on the saw and do not turn out on room drying, the lumber is case hardened, but the moisture content is uniform, use a temperature of 160 to 180 degrees and a humidity just high enough to moisten and soften the wood for a period of six to twenty four hours, but do not have

a humidity high enough to allow the surface to take up too much moisture, or stresses may be revised on redrying.

If prongs remain turned out after room drying the inner zones are set in an expanded condition and the stock should be treated about 24 hours, depending on thickness, at a temperature of 165 to 185 degrees, and 65 to 70 percent relative humidity for lumber where the inner zones contain between 7 and 12% moisture, and from 70 to 80% relative humidity when the center contains 12 to 15% moisture. Below an internal moisture content of seven percent conditioning may be dangerous and above 15% moisture this condition seldom occurs.

In all steaming or conditioning processes the kiln and lumber must be cooled to operating temperatures and humidity conditions high enough to prevent drying must be maintained during the period of cooling.

These tests apply for examination of lumber during kiln drying or to determine when to remove from kiln. No condition of lumber can be assumed without careful examination and tests. Any rule of thumb methods will, in all probability, either give an inferior product or require a uselessly long time with resultant extra costs.

A reduction of time of drying can only be accomplished by vigilance and an exact knowledge of all conditions, at all times.

A superheated steam process which will dry lumber from the green state to 10 percent moisture in 24 hours or less has been worked out at Madison for some lumber, such as Firs, Western Hemlock, Western and Southern Yellow Pine. This is carried on by forcing superheated steam at high velocity in alternate direction through the kiln. This consumes more steam than the older process and temperatures must not be maintained for more than two or three days. The writer has been asked if any special processes had been developed for drying Oak timbers. There are schedules for oak up to two or three inches in thickness, and there is no reason to doubt that much larger sections could be treated with equipment, where all conditions of temperature and humidity are under perfect control. However, some types of Oak are very difficult to handle, and it all depends on whether the results obtained are worth the possible loss, time, trouble and cost of treating this timber.

There have been questions as to whether the kiln dried lumber is equal to air seasoned lumber. To this I would say

that lumber in general is just as good if properly kiln dried as if air seasoned, it should be better, because in the kiln all factors can be kept under control, whereas in air the temperature and relative humidity is beyond human control and may vary decidedly from time to time.

There is a feature in connection with kiln drying in which most of you are more or less directly interested—to what extent should the drying process be carried and what moisture should be left in the wood when it is used for the various purposes.

The final moisture content of wood is a function of the temperature and the relative humidity of the atmosphere to which it is exposed. If it is too wet it will dry out and shrink. If it is too dry it will take up moisture and expand. The relative humidity has far more effect than the temperature, but this is often affected by a change in temperature.

The curves, as shown by Figure 1. show clearly the variation of the resultant moisture in wood as these factors change. All moisture results in this paper and references are based on percentage of water to the basis of the dried samples, and not as it is often calculated on the basis of the sample received. This practice has been adopted by the technical experts in their work and researches, and will undoubtedly come into universal practice. For instance, a sample weighing six pounds dries to four pounds. Instead of dividing the loss by six it is divided by four (the dry weight) giving 50% moisture.

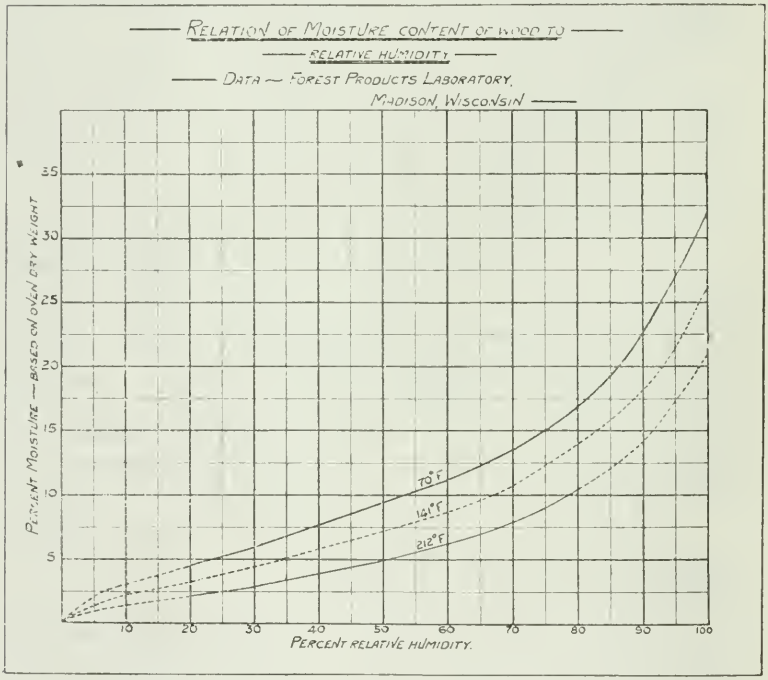
It has been noted on some specifications that the moisture calculations have not been defined and may thereby lead to misunderstanding and controversy.

Of course, time is required for changes to take place in wood just as in the drying kiln, but lumber exposed to a uniform atmospheric temperature and relative humidity will ultimately reach a resultant moisture content, irrespective of species.

Some of you are interested in car construction, others in furniture or domestic construction. The writer, for instance, enquired of several parties in the United States and Canada if they had records of the moisture content of lumber taken from cars, old buildings, or furniture. Since no data seemed to be available, numerous samples were taken from different parts of cars under repair at Montreal, and samples of wood which had been stored in heated buildings during and previous to the middle of December of last year. The results obtained should not be considered as conclusive for other places, or

other periods, but are given as an idea of what experimental work or studies should be undertaken by individuals interested in the different phases of wood construction.

That they may be better understood by all, these results are reported both on the basis of the samples as received and on the oven dry weight:—



	% Moisture on basis of original sample.			%Moisture on basis of dry sample		
	Max.	Min.	Ave.	Max.	Min.	Ave.
Box Car sheathing and lining	12.8	9.8	10.7	14.6	10.9	12.0
Decking (Car)	18.3	11.0	13.8	22.4	12.2	16.1
Roofing (Car)	28.7	9.6	18.9	40.6	10.5	24.3
Car Frame Timbers	14.0	10.0	11.9	16.6	11.0	13.5
Wood stored in heated building	6.7	5.4	6.2	7.2	5.8	6.6

Some of these results, of course, may be due to lumber becoming dry indoors and others exposed to water.

Records from various parts of the United States show that the lowest average humidities are 32% for the Spring and Summer at Phoenix, Arizona. Here at these seasons the natural moisture content of wood is five or six percent on the dry basis, whereas the average Winter humidity at Galveston is 84%, giving a natural equilibrium of 18 to 20 percent of the dry weight.

The meteorlogical records of Canada were examined by the writer from 1916 to 1921. The lowest average humidity for any month was found at Moose Jaw. The temperature was 70 degrees, and humidity was 57%. This would give wood a moisture of eleven percent if left there long enough, or, as some of us calculate, 10% on the basis of the original sample. The wettest month was at the same place, with a humidity of 92% at 33 degrees F., or a moisture content to wood of 22½% dry weight, or 18½% on the original weight.

The maximum monthly humidity of Montreal was 85%, and the minimum 62% or an average for a period of years of 72% and average temperature of 42.5 degrees F. Therefore, we would expect the natural mean moisture content of wood here to be about 15% on the dry basis or 13% on the original basis.

The speaker has meteorlogical data tabulated, showing temperatures and relative humidities of various sections of the United States and Canada, extending over periods of years, and should this data be of particular interest to any of you I would be glad to show it to you at any time.

Thank you.

Chairman:

I would like to state, gentlemen, that Mr. Farey, owing to an unusual pressure of business during the holiday season, was unable to prepare his paper sooner, in order that we might have had advanee· eopies. However, the reading of Mr. Farey's paper, you will agree, has been very interesting indeed. I assure you, speaking for myself, I have learned something about kiln dried lumber which I did not know before, and there are no doubt many here to-night who will take up the various phases of this subject in the discussion about to take place. The meeting is now open, gentlemen, and we trust to hear from some of you who are more or less familiar with the subject.

Mr. E. R. Viberg:

I had so much to say at the last meeting that I hesitate to say a great deal to-night. However, I must congratulate Mr. Farey on his excellent paper and the able manner in which he has treated the subject. There is a lot to learn in connection with the kiln drying of lumber, and one thing that is of particular importance in this process is the length of time required to dry Oak. We have had some experience in drying Oak without any very gratifying results. It takes a long time to learn the most effective means of drying Oak. Another thing, if you take lumber out of the kiln at 4 or 5% and it lays in the shop for some time, what is the result?

Mr. F. O. Farey:

The question of the length of time required to dry Oak is an uncertain one, and if you had all the means possible for so doing, a great deal would still depend upon the moisture which the sample contains in the beginning and, to a very large measure, on how carefully you can control the humidity of the kiln. If it is under very nearly absolute control, you can probably reduce the time required materially over what you can do if you had to keep it on the wet side to avoid cracking, and then, also, it depends upon the size of the lumber worked on.

Mr. E. R. Viberg:

6″ x 6″ sections of green Oak is what I have reference to.

Mr. F. O. Farey:

If you take the lumber out of the kiln in such dry condition, it will, undoubtedly, immediately begin to take up moisture depending, of course, upon the atmospheric temperature and humidity of your shop. Left out long enough, it would come up to 10 or 11%. If properly dried originally, it should not be case-hardened but would most likely swell up in proportion to the moisture absorbed. If, however, the fibres had set in an expanded condition, you might not get this expansion. The stresses would be relieved and then expansion or shrinkage would take place according to the moisture variation.

Mr. W. E. Buckle:

It was my intention to ask the same question regarding 8″ x 12″ sections of Oak, as to the temperature, etc., desirable for drying green Oak; that is, I would like to know the pro-

per temperature and percentage of moisture, if possible?

Mr. F. O. Farey:

I cannot state that Oak timbers 8" x 12" actually have been properly kiln dried. There has been a lot of experimental work carried out and a lot of excessive losses. A lot of this loss is, no doubt, due to not having proper control over the humidity and other conditions in the drying. Kiln drying of Oak in 1½" to 2" sections is started at 80% to 90% humidity for green timber and a temperature of not over 105 deg. F. It is rather indefinite, however, for large sections.

Mr. W. E. Buckle:

Would you recommend a low uniform temperature of the kiln for the drying period?

Mr. F. O. Farey:

In this connection I cannot give actual figures. Your temperature would probably reach about 140 deg. F. and the humidity down to 40% near the end of the process.

Mr. Parsons:

Could you dry green lumber in the old type of kiln without any humidifying apparatus, without checking?

Mr. F. O. Farey:

I do not see how you could help it with lower temperatures and longer drying periods.

Mr. M. Mahoney:

I do not happen to be a member of this Club, but this being a familiar question, I am interested. I have had considerable experience in handling lumber—probably 50 years—and I would like to deal with the question raised by both Mr. Viberg and Mr. Buckle. It would be utterly impossible to kiln dry Oak 8" x 12" as it would all be split in the process. This, gentlemen, is my opinion of trying to kiln dry a piece of Oak the size mentioned. It is, however, different with the smaller sizes of Oak. You can kiln dry Oak, but above all, you must have this lumber properly air dried before kiln drying to obtain results.

Mr. E. R. Viberg:

During the War, Oak was used somewhat extensively for Carriages, etc., and at that time it was not dried successfully. In some cases it took 3 or 4 months before this could be dried.

Mr. F. O. Farey:

Most of the better investigations have been carried on in the last 4 or 5 years.

Mr. R. J. Needham:

I noticed in the discussion the speaker used the term "live steam." About what temperature was the steam?

Mr. F. O. Farey:

I think that live steam is delivered at 70 lbs.

Mr. G. M. Wilson:

I would like to ask if the temperature is automatically regulated, or by hand?

Mr. F. O. Farey:

They have automatic regulators, but a great deal of it is carried on by hand. The temperature is changed as the drying progresses and the conditions of the lumber require

Mr. W. E. Buckle:

Can we get any statistics about the drying of large sized Oak?

Mr. F. O. Farey:

I think the best thing on that is to see what has been recently done down at Madison. I have here, however, a schedule for 1½" or 2" Oak. The initial temperature was 105 deg. F. and 85% humidity when original stock contained 40% moisture on the dry basis. The final temperature was 135 deg. F. and 40% humidity after the lumber was down to 10%. Intermediate changes of 5 degrees temperature, and 5 or 10% relative humidity were made for each 5% reduction of moisture in the stock.

For each extra inch in thickness the next milder schedule is used which would mean a reduction of initial temperatures of five degrees with 85% humidity remaining constant for each extra inch thickness. There would be no use increasing the humidity above 85% or no drying would take place. Also there would be no object in reducing temperatures below 80 to 90 degrees.

Mr. M. Mahoney:

Suppose, for instance, with live steam poured into Oak for 24 hours and that it is steamed so that it will cut, as for

instance, the cut of staves with a knife, this wood is dry after cooling, what would be the effect on Oak?

Mr. F. O. Farey:

Personally, I do not know as I have never heard of it.

Editors Note.

(The following has been received from Mr. F. O. Farey since the meeting.)

Since reading my paper an article appears in the Journal of the Society of Chemical Industry of England under date of December 30th, 1922.

This covers the "Artificial Seasoning of Wood by the Ozone Process."

The process was invented and patented by M. Otto, and consists of subjecting green timber to the action of ozonized air, which changes starchy substances to sugars and the resinifiable substances and undergo oxidation to form solids.

The claim is made that wood can be treated from ten to fifteen days giving the same results as ten years seasoning; also wood so treated does not shrink or expand as under other treatments.

Mr. G. M. Wilson:

Well, gentlemen, if no one has anything further to say on this interesting subject, I would ask one of you to kindly move a vote of thanks to Mr. Farey for his most able paper.

Mr. L. Brown:

I take great pleasure in moving a hearty vote of thanks to Mr. Farey—Seconded by Mr. Buckle.

President:

For the next meeting of the Club, in February, we have a subject by Mr. Wm. S. Cookson, General Passenger Agent, Grand Trunk Railway, on how Railway Tickets are prepared, printed and handled, and will be pleased to see as many of you as can attend this meeting.

The next gathering together of the "Clan" will be on the 27th of January when, no doubt, we will have, as in times past, a pleasant evening.

We will now close, and Refreshments will be served in the adjoining room to the right.

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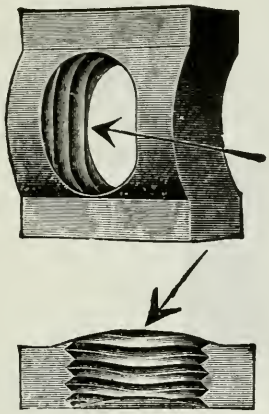

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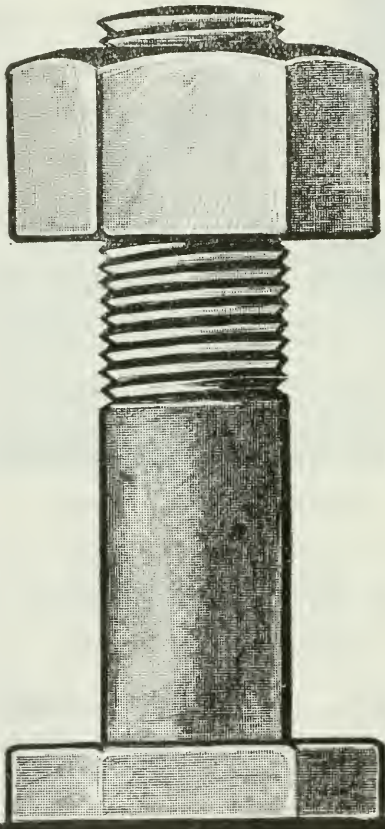

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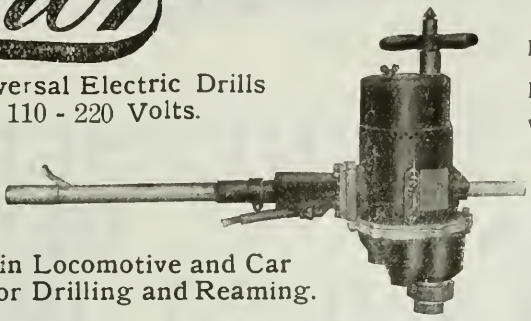

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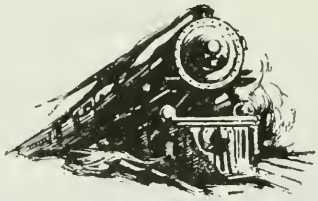

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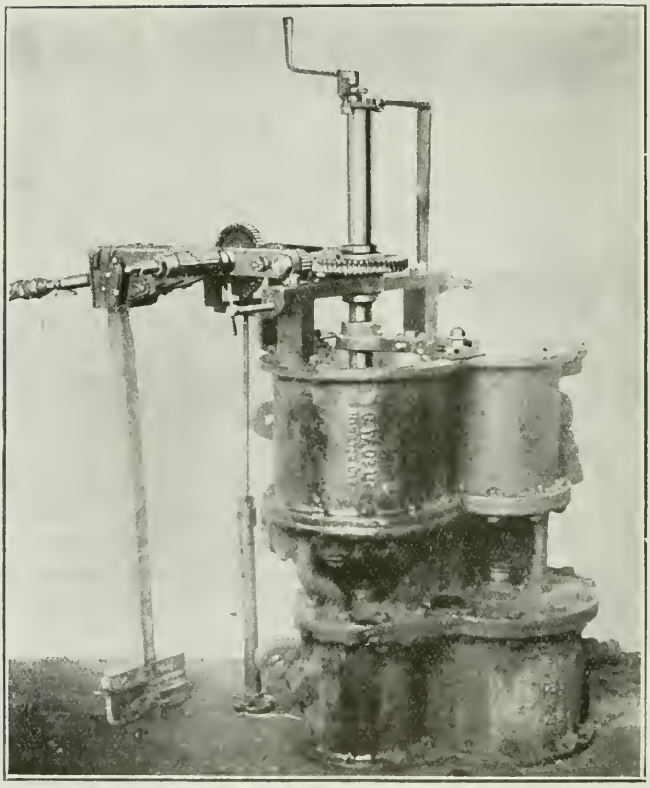

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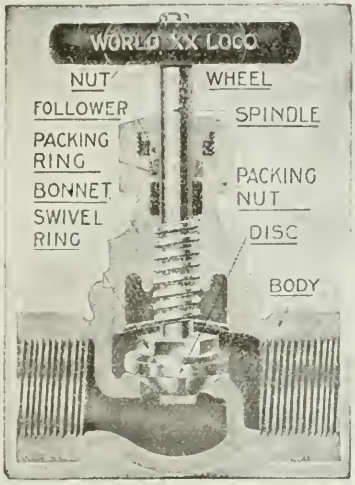

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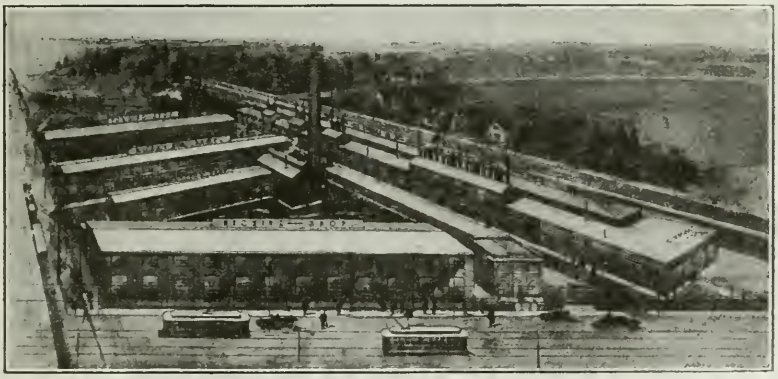

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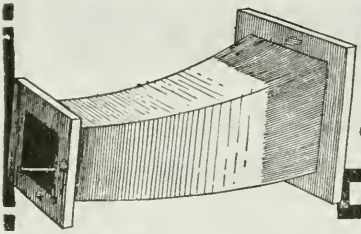

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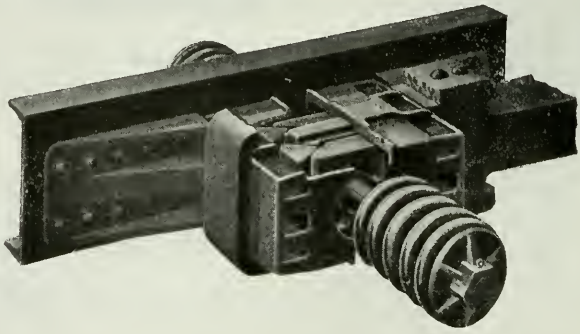

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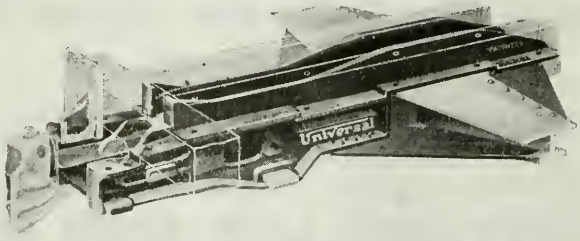

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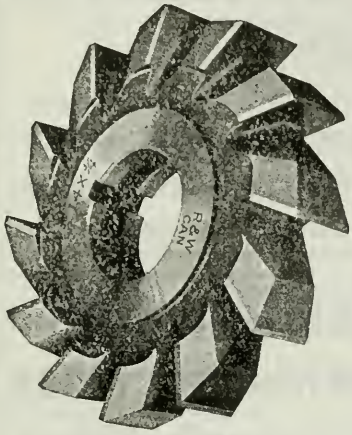

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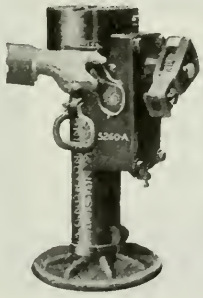

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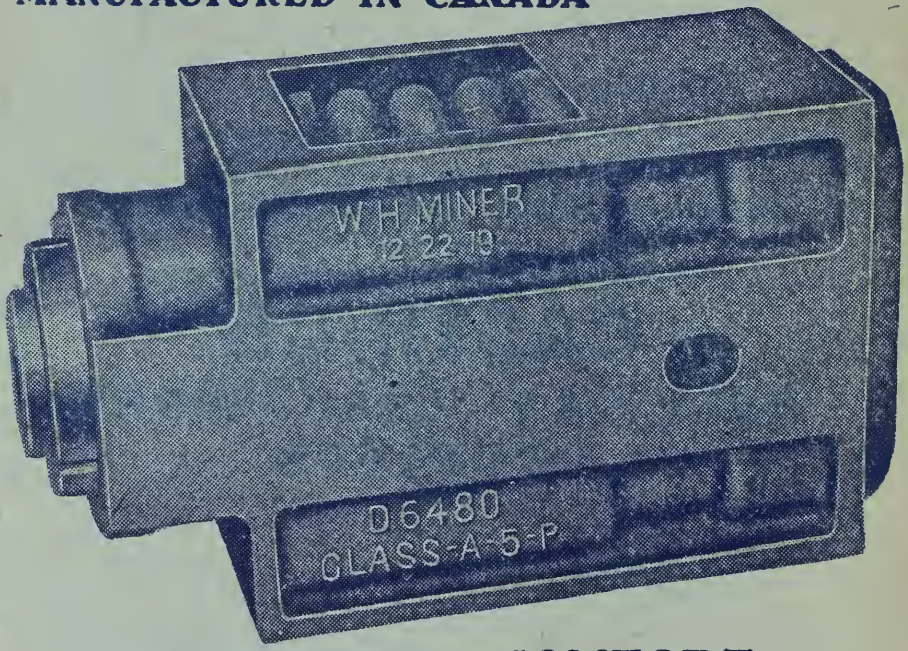

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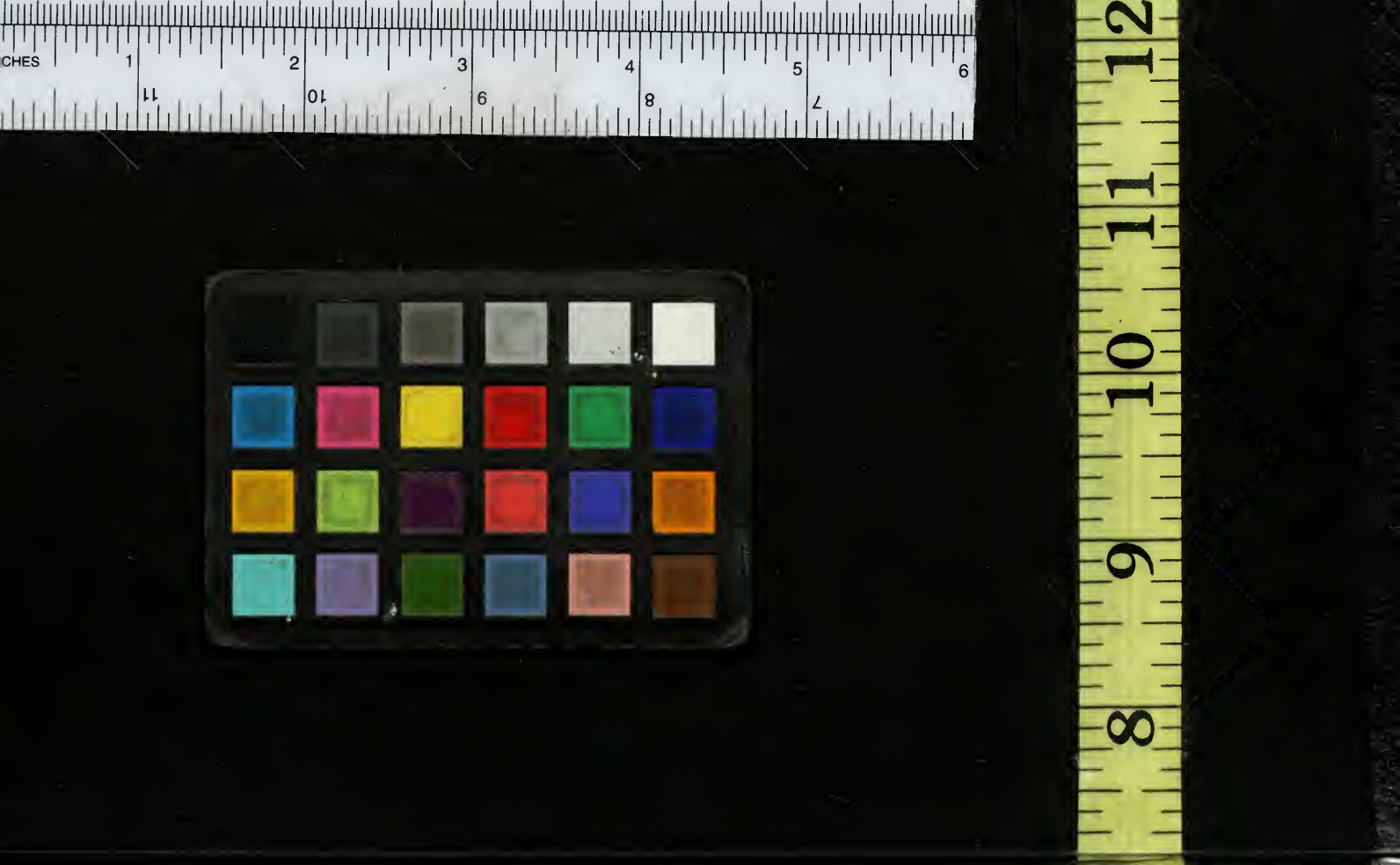
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